Preparation, irradiation, and characterization of surfaces under ultra high vacuum conditions

F. Meinerzhagen[1], H. Bukowska[1], T. Peters[1], O. Picht[1,2], D. Severin[2], M. Bender[2], A. Siegmund[2], H. Lebius[3], F. Weiss[1], and M. Schleberger[1,#]

[1]Universität Duisburg-Essen, 47057 Duisburg, Germany; [2]GSI, 64291 Darmstadt, Germany; [3]CIMAP, 14070 Caen Cedex 5, France .

A scanning probe microscope (SPM) in an ultra-high-vacuum (UHV) enviroment was built up at the M-branch of GSI. With this new facility it is possible to characterize modifications caused by ion irradiation in-situ with a resolution down to atomic scales.

Experimental setup

A picture of the experimental setup is shown in fig. 1. Tips for the SPM, samples or substrates can be transferred to UHV from a load-lock. Samples can be heated with an electron beam or a direct current heater on a manipulator in the preparation chamber. An electron beam evaporator in this chamber allows to deposit two different materials on the sample. For controlling the mass flow a microbalance can be used. A low energy electron diffraction (LEED) unit enables the investigation of sample crystallinity. The main part of the setup is the commercially available VT SPM (Omicron NanoTechnology). It allows atomic force microscopy (AFM), scanning tunneling microscopy (STM), and special modes of AFM like Kelvin probe force microscopy (KPFM) for spatially resolved measurements of surface potentials. The irradiation chamber permits irradiation of samples under glancing incidence ($\theta < 5°$). Currently the accuracy of the angle is ± 1°, but in the final stage it will be down to ± 0.05°. In addition to the angle, the energy deposition is an important parameter for our experiments. The ions are accelerated by the linear accelerator UNILAC and have energies in the range of 3.6 to 11.4 MeV/u. We are interested in single ion induced modifications in low-dimensional solids and therefore use fluences on the order of 10^{10} ions/cm^{-2}.

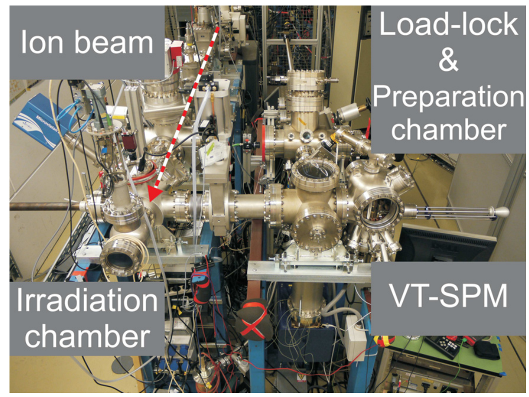

Figure 1: Picture of the setup. The irradiation chamber is mounted at the end of the ion beam line (marked with the arrow). In the upper right part of the picture the preparation chamber can be seen, below the chamber with the SPM.

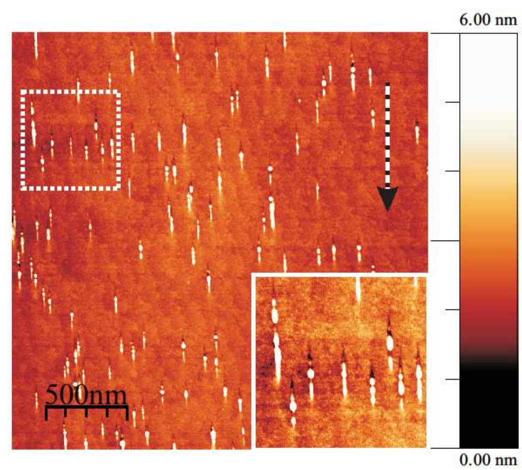

Figure 2: AFM image of a $SrTiO_3$ surface (Δf = -23 Hz). The sample was irradiated under an angle of $\theta = 4° \pm 1°$ with $^{238}U^{28+}$ and an energy of 857 MeV. The stopping power was 48 keV/nm. The arrow marks the direction of the ion beam.

First results

At the first beamtimes we could demonstrate that the newly built system works as planned. Figure 2 shows an AFM image of a successfull irradiated strontium titanate ($SrTiO_3$) surface with stopping power of 48 keV/nm. On the crystalline $SrTiO_3$ chains of hillocks with a height up to 6 nm are observable. This phenomenon has been observed before for $SrTiO_3$ irradiated with ions with stopping powers up to 25 keV/nm [1-3].

We also found a new structural feature in form of a few Ångström deep rift at the beginning of the trajecory (see inset in fig. 2). This effect will be studied in future experiments with our new setup.

References

[1] E. Akcöltekin, T. Peters et al., Nature Nanotech. 2 (2007) 290

[2] E. Akcöltekin, S. Akcöltekin et al., New J. Phys. 10 (2008) 053007

[3] S. Akcöltekin, E. Akcöltekin et al., Nucl. Instr. Meth. B 267 (2009) 1386

#marika.schleberger@uni-due.de